

## ***Interactive comment on “Comparison of the cloud top heights retrieved from MODIS and AHI satellite data with ground-based Ka-band radar” by Juan Huo et al.***

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### General comments

The paper of Huo et al compares the cloud top height retrievals of MODIS collection 6, AHI product distributed by JAXA and a ground based Ka-band radar for the region of Beijing. It discuss the differences of the products as function of the cloud base height and cloud depth. The paper is clearly structured and sufficiently well written, but some formulations could be clearer and some typos has to be corrected. These findings are interesting for users of the satellite cloud top height CTH products. The paper would gain a lot, if MODIS and AHI are compared to the Ka-band radar exactly in the same

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way (plot Fig 4a and 7a in the same way, plot 4b also for AHI, plot 7b also for MODIS, plot Fig 5 for AHI. . .). The paper would also gain by an extended discussion, e.g. the difference between the radiatively effective CTH (expressed here as “radiation center of the cloud”) and the radar CTH was first mentioned in the summary. It might be worth to include a complete discussion chapter. I support that a small summary of the Håkansson et al. 2018 should be included here.

### Specific comments

Line 12: Specify here, that you refer to cloud base height: “especially clouds higher than 4km” e.g. write especially when the cloud base height is higher than

Line 12/13/14: Like Nina Håkansson mentioned, these lines should be reformulated, maybe like this: MODIS CTH larger than 6km show a good agreement with the radar CTH when the cloud depth is large and larger differences when the cloud depth is small.

Line 15: I am a bit puzzled by this: The average MODIS CTH is 1.1km lower than the average CTH of the Ka-band. The average AHI CTH is 1.1km lower than the average CTH of the Ka-band. But still the average AHI CTH is 0.64 km lower than the average MODIS CTH. Shouldn't the difference between AHI and MODIS be close to 0 km? Could you comment on this, please?

Line 21: clouds to influence GCM by many more processes, e.g. water transport, radiative transfer, lightning activity, aerosol transport...; maybe write: “for example” as the cloud vertical distribution determine. . .

Line 24: replace “modeled stratocumulus CTHs with satellite retrievals” with “stratocumulus CTHs retrieved from satellite observations”

Line 19 to 24: could be written a bit more smoothly.

Line 30: IR brightness temperature of “the” cloud

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Line 30: for instance, “that a” cloud. . .

Line 31: Ground based lidar often does not detect cloud tops.

Line 35 to 45: The references of the MODIS validation that are discussed more in detail are all very old (1999, 2002, 2008). As this paper deals with MODIS collection 6, I suggest to update this section.

Line 51: Mouri et al (2016) found that the CTH (of a ground based radar? where?) was underestimated?

Line 48 / 51: Zhou says that CTH by ground based radar are higher compared to satellite CTH (AHI), but Mouri says CTH (by ground based radar?) was underestimated compared to satellite CTH (MODIS). Could you comment on why the results are different, please.

Line 35 to 57: might be better structured: describe roughly satellite and ground based CTH retrievals, comment on their differences describe global evaluations and describe expected differences (state of the knowledge today); write why local evaluations are important; reason, why this paper brings additional insight; comment on, why the region of Beijing is interesting

Line 71: I suggest to move the equations after the sentence: Equation (1) to (3) present the theory of the CO<sub>2</sub>-slicing technology.

Equation 1:  $R_{clr}$  must be written in large letters; please explain  $R_{bcd}$  in the text below (I guess this stands for radiance of clouds with emissivity of a black body)

Equation 2 and Equation 3: “dp” is missing at the ends of each integral; You could add a citation here for these equations, e.g. the CLOUD TOP PROPERTIES AND CLOUD PHASE ALGORITHM THEORETICAL BASIS DOCUMENT, Menzel et al.

Line 74: replace "is the radiance measured" with "is the measured radiance"

Line 81: give a few examples of MODIS collection 6 evaluations

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Line 83: the spatial resolution (of the cloud product?)

Line 92: target area and landmark areas

Line 95: radiative transfer code (Eyre 1991) developed by EUMETSAT “with” input

Line 104: Avoid the brackets The Ka-band polarization Doppler radar “using a wavelength of 8.55 mm”

Line 133ff: reformulate the last 3 sentences: Zhou used -40 dBZ, but in this study we choose -45 dBZ, as we wanted to include clouds with weak return signals.

Line 127: specify what you mean by “period”

Table 1 add space between number and physical units

Line 126 to 131: this is already comparison technique and should be move the chapter 3

Line 128: I don't understand this sentence: “For multi-layer clouds, the CTH is also the average of all cloudy profiles even if the upper-level cloud do not cover the lower-level cloud, rather than the average CTH of the upper-level clouds.”; Does the upper-level cloud not always cover the lower level cloud by definition? Please comment on, why you choose to average the CTH of the upper cloud layer and the lower cloud layer. (If I understand this correctly.)

Line 131: Could you comment on the accuracy of the Radar CTH measurement, please. Does the radar always sees the uppermost cloud boundary. Or is it possible that attenuation is so strong that you cannot see through the cloud, e.g. during a strong precipitation event.

Line 137: Improve sentence: “MODIS CTH data measured transiently cover an area”

Line 137/138: use superscript for exponents  $\text{km}^{**2}$  and  $\text{m s}^{**}-1$

Line 138: “line” -> a scanning line with constant elevation

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Line 138: what about wind speeds below and above 10 m/s?

Line 147: I would reformulate this: “the MODIS spatial resolution has been increased”; Maybe: depending on the viewing geometry of the individual satellite overpasses, the sampling location and their distances from each other vary, see Fig 2.

Line 148: Please specify more clearly “the climatological distribution of clouds”. Do you refer here to the distribution of the cloud movement?

Line 156: Please specify north-south and east-west resolution of the AHI product. Maybe add: "Due to the Himawari-8 viewing geometry", the AHI CTH data have . . .

Line 164: difference between the radar and MODIS (AHI) -> difference between MODIS (AHI) and the radar

Equation 4: write this as two equations to avoid confusion with the notation  $f(x)=y$

Line 173: add plus-minus signs here: less than “+/-“0.25 km, . . . less than “+/-“0.5 km, . . . less than “+/-“1.0 km

Line 175 / Figure 4: I suggest to make Fig 4 and Fig 7 the same, so that it is easy to compare.

Line 191 / Figure 5: In the text, you discuss CTH difference as a function of cloud depth (5a) and CTH difference as a function of CBH. Therefore, I suggest to swap x and y-axis. I also suggest to do a similar figure also for the CTH comparison between AHI and Ka-radar. You might consider to write “D\_mr” instead of “CTH Difference”

Line 204: Add more space between Table 2 and Line 204

Line 219++: make a italic “r” in D\_ar in this line and all following occurrences

Line 224 / Figure 7: For 7a, use same length for x and y-axis as well as same length. For 7b, you might consider to write “D\_ar” instead of “CTH Difference”

Line 231: . . . which might “be” due to

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Line 234 / Figure 8: In Fig 8a you might comment on the occurrence peaks of cloud optical thickness = 100 and 150.

Line 250 / Figure 9: You might consider to plot best fit lines in these diagrams.

Line 253-255: The description of the location “subtropical monsoon zone” might already be interesting in the reasoning, why you wrote the paper at the end of the introduction.

Line 265: Here a discussion chapter is missing.

Line 268: uncertainty of the theoretical assumptions -> uncertainty caused by the theoretical assumptions

Line 271: the CTHs retrieved from passive sensors ... were on average 1.1 km lower compared with the ...

Line 274: The argument, that the CTH retrieved by satellite

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